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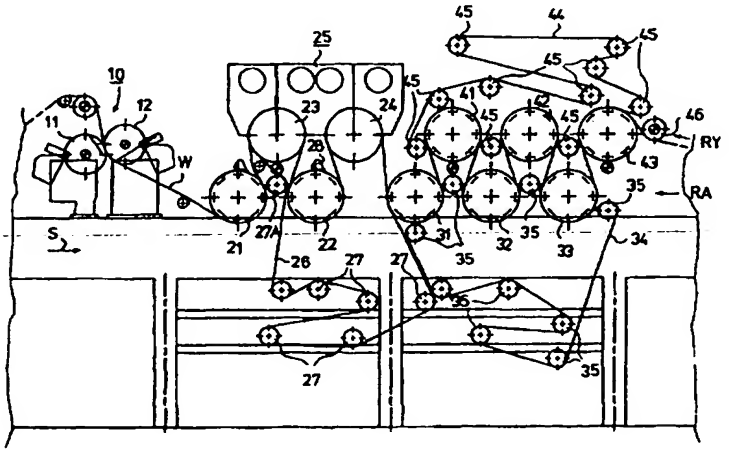
(54) Title: METHOD FOR DRYING A SURFACE-TREATED PAPER WEB OR EQUIVALENT IN AN AFTER-DRYER OF A PAPER MACHINE AND AFTER-DRYER CARRYING OUT THE METHOD IN A PAPER MACHINE



(57) Abstract

The invention concerns a method for drying a surface-treated paper web or equivalent in an after-dryer of a paper machine, in which method the paper web (W) is first finished in a finishing section, in which finishing section the paper web (W) is surface-sized or coated by means of a finishing device (10), after which the paper web (W) is dried. In the after-dryer the paper web (W) is dried in at least one dryer group that makes use of single-wire draw, and that, at the same time, the paper web (W) is dried by means of an impingement-drying equipment (25) fitted in connection with at least one cylinder or roll (23, 24) in said dryer group. Further, the invention concerns an after-dryer for a paper machine for applying the method to the drying of a surface-treated paper web or equivalent, which after-dryer is placed after the finishing device (10), by means of which finishing device (10) the paper web (W) is surface-sized or coated. The after-dryer comprises at least one dryer group that applies single-wire draw, and an impingement-drying equipment (25) is fitted in connection with at least one cylinder or roll (23, 24) in said dryer group.

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Method for drying a surface-treated paper web or equivalent in an after-dryer of a paper machine and after-dryer carrying out the method in a paper machine

The invention concerns a method for drying a surface-treated paper web or equivalent in an after-dryer of a paper machine, in which method the paper web is first finished in a finishing section, in which finishing section the paper web is surface-sized or coated by means of a finishing device, after which the paper web is dried.

Further, the invention concerns an after-dryer for a paper machine for applying the method in accordance with the invention to the drying of a surface-treated paper web or equivalent, which after-dryer is placed after the finishing device, by means of which finishing device the paper web is surface-sized or coated.

As is known from the prior art, in multi-cylinder dryers of paper machines, twin-wire draw and/or single-wire draw is/are employed. In twin-wire draw the groups of drying cylinders comprise two wires, which press the web one from above and the other one from below against heated cylinder faces. Between the rows of drying cylinders, which are usually horizontal rows, the web has free and unsupported draws, which are susceptible of fluttering, which may cause web breaks, in particular so when the web is still relatively moist and, therefore, of low strength. This is why, in recent years, ever increasing use has been made of said single-wire draw, in which each group of drying cylinders includes just one drying wire, on whose support the web runs through the whole group so that the drying wire presses the web on the drying cylinders against the heated cylinder faces, whereas on the reversing cylinders or rolls between the drying cylinders the web remains at the side of the outside curve. Thus, in single-wire draw, the drying cylinders are placed outside the wire loop, and the reversing cylinders or rolls inside said loop.

In the what is called normal groups with single-wire draw, known from the prior art, the heated drying cylinders are placed in the upper row and the reversing cylinders are placed in the lower row, which rows are, as a rule, horizontal and parallel to one another. On the other hand, in inverted groups with single-wire draw, the drying cylinders are, as a rule, placed in the lower row and the reversing cylinders in the upper row. In the following, when the terms "normal (dryer) group" and "inverted (dryer) group" are used, what is meant is expressly groups with single-wire draw in multi-cylinder dryers, of the sort mentioned above.

When paper is dried by means of normal groups with single-wire draw from the side of its bottom face and if such asymmetric drying is extended over the entire length of the forward dryer section, the drying takes place so that first the bottom-face side of the paper web is dried and, when the drying makes progress, the drying effect is also extended to the side of the top face of the paper web. Under these circumstances, the dried paper is usually curled and becomes concave, seen from above.

As is known from the prior art, the tendency of curling of paper is already affected in connection with the web formation, in particular at the sheet formation stage by means of selection of the difference in speed between the slice jet and the wire, and by means of other running parameters. As is known from the prior art, for example, in the case of copying paper, by means of unequalsidedness of drying in the after-dryer a suitable initial curl form is regulated for the sheet in order that the curling of the paper after one-sided or double-sided copying could be optimized. In the case of copying paper, the reactivity of curling, i.e. the extent to which curling occurs per unit of change in moisture content, is affected to a greater extent by means of a multi-layer structure of the paper, which is produced in connection with the web formation in the wet end.

The most recent technology related to the present invention in high-speed paper machines, in particular in fine-paper machines, has been based on dryer sections in which there is single-wire draw over the major part of the length of the machine, and, in view of controlling the tendency of curling of paper, in practice, an inverted

group has also been used in order that the drying could be made sufficiently symmetric in the z-direction.

From the prior art, solutions are known for an after-dryer for paper to be coated, in particular for fine paper or equivalent, in which dryer there is first an upper cylinder and a lower cylinder and after this one group that employs normal single-wire draw, and after that dryer groups that make use of twin-wire draw. In these applications, it is a problem that, in view of the tendency of curling of paper, the ratio of the upper and lower cylinders is wrong if the curling is supposed to be regulated efficiently. As is known from the prior art, in the after-dryer it has been necessary to keep the temperature of the first cylinders low because of adhering of the web and the size/paste to the cylinder. This is why the heating of the web on the cylinders either in single-wire draw or in twin-wire draw has taken an unduly high proportion of the length of the machine in relation to the capacity that is provided.

It is an object of the present invention to provide a solution in which the curling of paper is controlled so that the after-dryer does, however, not become substantially longer.

Groups of the sort mentioned above for finishing of paper to be coated, in particular of fine paper, have been described, among other things, in the applicant's *FI Patent Application No. 950434*. Thus, the object of the present invention is further development of the solutions suggested in said application so that the tendency of curling of paper can be controlled more efficiently in the after-dryer.

With respect to the prior art, reference can also be made to the applicant's *FI Patent Application No. 931263* (equivalent to *EP Application No. 0,620,313* and equivalent to *US Patent No. 5,495,678*), in which a favourable arrangement is described for combining impingement drying with a prior-art cylinder dryer group that applies single-wire draw.

It is a further object of the invention to provide such a solution for an after-dryer as is suitable for use in particular in dryer sections in which it has not been possible or desirable to control the curling of the paper web in the forward dryer.

It is a further object of the present invention to provide such an after-dryer for a paper machine in which the runnability can be brought to a particularly high level.

It is a further object of the invention to provide an after-dryer of a paper machine which has an efficient drying capacity.

From the prior art, it is known to use an electric or gas infra after a coating station or surface-sizing unit. Also, it is known from the prior art to use a what is called combination dryer, in which the hot air of a infra is passed into a what is called airborne web dryer.

It is a further object of the invention to provide an after-dryer for a paper machine which is advantageous in view of the consumption of energy.

A specific object of the invention is to create novel concepts for an after-dryer of a paper machine in which runnability, efficiency and control of curling are optimized.

In view of achieving the objectives stated above and those that will come out later, the method in accordance with the invention is mainly characterized in that in the after-dryer the paper web is dried in at least one dryer group that makes use of single-wire draw, and that, at the same time, the paper web is dried by means of an impingement-drying equipment fitted in connection with at least one cylinder or roll in said dryer group.

Further, the after-dryer in accordance with the invention that makes use of the method is mainly characterized in that the after-dryer comprises at least one dryer group that applies single-wire draw, and an impingement-drying equipment is fitted in connection with at least one cylinder or roll in said dryer group.

In accordance with one exemplifying embodiment of the invention, in the beginning of the after-dryer, an inverted group with single-wire draw is fitted, above whose suction rolls, suction cylinders or equivalent reversing rolls/cylinders impingement blowing hoods are placed. This solution is advantageous, because single-wire draw has a good runnability and does not require threading by means of a rope, and, moreover, impingement drying dries the coated side of the paper web efficiently. By means of this arrangement, among other things, the advantage is obtained that the web is heated quickly, whereby efficient evaporation of the water present in the web surface is achieved. The impingement blowing does not affect the curling, and the curling is regulated in the following group with twin-wire draw by adjusting the steam pressures in the upper and lower cylinders to suitable levels. The arrangement in accordance with the invention permits the construction of a shorter after-dryer and has a better energy economy than infrared dryers etc. devices based on electric energy, because in impingement drying it is possible to use, for example, combustion gases from liquefied petroleum gas, which are more advantageous than electricity. Compared with an airborne web dryer, an important advantage of the system in accordance with the present invention is good runnability. Moreover, in the arrangement in accordance with the invention, the efficiency can be regulated readily and, also, the impingement drying provides a possibility for profiling.

In an arrangement in accordance with a preferred embodiment of the present invention, impingement drying is applied to the drying of a coating and, in the same way as in a combined infrared/airborne-web dryer, the air heated by the infra is utilized in the impingement drying unit. Warm air can be used as replacement air for the impingement drying unit, and also directly as impingement blow air, to replace air that has to be heated otherwise, or it can also be used as pre-heated air for a burner by whose means said blow air is heated. In view of the efficiency, a situation is particularly favourable in which gas infra dryers are available. In such an arrangement, in connection with the after-dryer, after the coating or surface-sizing device, before cylinder drying and impingement drying units, there is a gas dryer or gas-infra dryer in pre-drying. Advantages that are obtained include economies of energy and good draw of the web.

In the following, the invention will be described in more detail with reference to the figures in the accompanying drawing, the invention being, however, in no way supposed to be confined to the details of said illustrations.

Figure 1 is a schematic illustration of an exemplifying embodiment in which, in the beginning of the after-dryer, there is a dryer group that makes use of single-wire draw, in which group the reversing rolls/cylinders are provided with an impingement drying device and which group is followed by a dryer group with twin-wire draw.

Figure 2 is a schematic illustration of an after-dryer substantially similar to that shown in Fig. 1, in which dryer the first drying equipment is an airborne web dryer.

The exemplifying embodiment that is illustrated schematically in Figure 3 is substantially similar to those shown in Figs. 1 and 2, but in this embodiment, after coating, the web is turned by means of a reversing blow box.

Figure 4 is a schematic illustration of an exemplifying embodiment in which, after coating/surface-sizing, the web is turned by means of a reversing blow box, passed into an inverted dryer group that applies single-wire draw and in which impingement drying devices are fitted in connection with the reversing rolls/cylinders, after which there follows a dryer group that applies twin-wire draw.

Figure 5 is a schematic illustration of an exemplifying embodiment which is substantially similar to that shown in Fig. 4, but the drying cylinder in the inverted dryer group with single-wire draw has been substituted for by a reversing blow box.

Figure 6 is a schematic illustration of an exemplifying embodiment in which the first dryer group is a group with normal single-wire draw, in which group, in connection with the reversing rolls, impingement drying units are fitted, which are followed by a dryer group with twin-wire draw.

Figure 7 is a schematic illustration of an exemplifying embodiment in which the first group in the after-dryer is a normal dryer group with single-wire draw, which group is followed by a second normal group with single-wire draw, in which group impingement drying devices are fitted in connection with some of the reversing rolls.

Figure 8 is a schematic illustration of an exemplifying embodiment which is substantially similar to that shown in Fig. 7, but the first dryer device in the after-dryer, before the groups with single-wire draw, is an airborne web dryer.

Figure 9 is a schematic illustration of an exemplifying embodiment in which an airborne web dryer equipment is followed by a normal dryer group with single-wire draw, after which group a cylinder of very large diameter is placed, in connection with which cylinder impingement drying devices are fitted and which cylinder is followed by a normal dryer group that applies single-wire draw.

Figure 10 is a schematic illustration of an exemplifying embodiment in which the first dryer group in the after-dryer is provided with a reversing cylinder/roll of large diameter, in connection with which impingement drying devices are fitted and which is followed by a dryer group that applies twin-wire draw.

Figure 11 is a schematic illustration of an exemplifying embodiment in which the first group in the after-dryer is a group with twin-wire draw, which group is followed by an inverted dryer group with single-wire draw, followed by a dryer group that applies twin-wire draw.

Figures 12A and 12B are schematic illustrations of an exemplifying embodiment of the nozzle face of an impingement drying device.

Figure 13 is a schematic illustration of an exemplifying embodiment in which, in the beginning of the after-dryer, connected with the first cylinder, an infra dryer is fitted, whose heat is used in connection with impingement drying, and in which, between the infra and the impingement dryer, a reversing blow equipment is fitted.

Figure 14 is a schematic illustration of an exemplifying embodiment in which, after the coating, the web is dried by means of an infra dryer or a gas dryer, whose heat is utilized in impingement drying, and in which, after the infra dryer, a reversing blow box is fitted, which is followed by an impingement dryer group.

In Fig. 1 the coating device is denoted with the reference numeral 10, and the coating device 10 is, for example, a coating device marketed by the applicant with the name **SYM-SIZER™**, which device comprises two opposite coating rolls 11 and 12, in connection with each of which there are size feed devices so that the paper web W is coated from both sides in the coating nip between the rolls 11 and 12. After this, the web W is passed into the after-dryer onto its first drying cylinder 21 placed in the lower row RA, over which the web W is passed into its inverted dryer group with single-wire draw, onto its first reversing roll/cylinder 23 in the upper row RY, from which the web W is passed by means of the drying wire or an equivalent support fabric 26 onto the drying cylinder 22 in the lower row RA and further onto the reversing roll or cylinder 24 in the upper row RY. In connection with the reversing rolls or cylinders 23,24 in the upper row RY, and impingement blowing equipment 25 is fitted, by whose means drying gas/air jets are blown towards the web W. The guide rolls of the drying wire 26 are denoted with the reference numeral 27, and by means of the guide roll 27A the run of the drying wire 26 is shifted so that it does not reach contact with the web W to be dried that runs over the drying cylinder 21. From the reversing roll/cylinder 24, supported by the drying wire 26, the web W is passed as a closed draw into a dryer group with twin-wire draw onto the first drying cylinder 31 in its lower row RA. In the figure the drying cylinders in the lower row RA are denoted with the reference numerals 31,32 and 33, over which cylinders the web W runs alternating and meandering onto the drying cylinders 41,42 and 43 in the upper row RY. The drying wire 34 of the lower-row RA cylinders 31,32,33 runs guided by the guide rolls 35, and the drying wire 44 of the upper row RY runs guided by the guide rolls 45. Over the guide roll / alignment roll 46 the web W is passed to further processing. In connection with the drying cylinders, a doctor 28 can be provided.

As the reversing rolls/cylinders, particularly favourably are used the suction cylinders marketed by the applicant with the trade mark "**VAC-ROLL**"™ and provided with no inside suction box, reference being made, with respect to the details of the constructions of said rolls, to the applicant's *FI Patent No. 83,680* (equivalent *US Patents Nos. 5,022,163* and *5,172,491*). In stead of the Vac-Roll suction cylinders, it is also possible to use rolls *marketed by the applicant with the trade mark UNO* or cold or hot cylinders in themselves known.

The exemplifying embodiment shown in Fig. 2 is substantially similar to that shown in Fig. 1, and corresponding parts are denoted with the same reference numerals. Unlike the exemplifying embodiment shown in Fig. 1, in Fig. 2 the web W coated by means of the coating device 10 is first passed through an airborne web dryer 15, which operates as a pre-dryer, before the first drying cylinder 21.

The exemplifying embodiment shown in Fig. 3 is substantially similar to those shown in Figs. 1 and 2, and corresponding parts are denoted with the same reference numerals. It is a difference in this exemplifying embodiment that after the coating device 10 the paper web W is passed over a reversing blow device 14 into an airborne web dryer 15 operating as a pre-dryer, and from the airborne web dryer 15 directly onto the first reversing roll/cylinder 23 in the upper row RY in an inverted group with single-wire draw.

The exemplifying embodiment shown in Fig. 4 is substantially similar to the exemplifying embodiments shown in Figs. 1 to 3, but in this exemplifying embodiment, after the coating device 10, the web W is passed over a reversing blow device 14 directly onto the first reversing roll/cylinder 23 in the upper row RY in an inverted group with single-wire draw.

The exemplifying embodiment shown in Fig. 5 is substantially similar to that shown in Fig. 4, but here the drying cylinder 22 in the lower row RA in the first inverted dryer group with single-wire draw has been substituted for by a reversing blow device 28.

In the exemplifying embodiment shown in Fig. 6, the coated web W is passed from the coating device 10 over the drying cylinder 21 onto the first drying cylinder 51 in the upper row RY in a normal dryer group with single-wire draw. This dryer group comprises two drying cylinders 51 and 52 in the upper row RY and two reversing rolls or cylinders 53,54 in the lower row RA. In connection with the reversing rolls/cylinders, an impingement drying equipment 55 is fitted. The drying wire is denoted with the reference numeral 56 and the guide rolls with the reference numeral 57. After this dryer group the web W is passed as a closed draw by means of the drying wire 56 onto the first drying cylinder 41A in the upper row RY in a dryer group with twin-wire draw. In the other respects the dryer group with twin-wire draw is similar to the twin-wire draw illustrated in the preceding figures.

In the exemplifying embodiment shown in Fig. 7, the coating device 10 is followed by a dryer group with normal single-wire draw, into which the coated paper web W is passed over the drying cylinders 61 and 62. Supported on the drying wire 66, the paper web W to be dried runs meandering over the reversing rolls/cylinders 65 in the lower row RA and the drying cylinders 63 in the upper row RY onto the drying cylinder 64, from which the web W is passed into the next dryer group with normal single-wire draw as a closed draw onto the drying wire 76 of said group, on whose support the paper web W runs meandering over the reversing rolls/cylinders 75,78 in the lower row RA and the drying cylinders 73 in the upper row. In connection with the middle reversing rolls/cylinders 78 in the lower row, impingement drying devices 79 are fitted for further drying of the web by means of drying blowings. Over the drying cylinder 74 the web W is passed to further processing. In dryer groups with single-wire draw blow boxes 68 or equivalent are used, for example devices 68 which are marketed by the applicant with the trade mark **UNO-RUN-BLOW-BOX** and which improve the runnability. Of course, these devices can also be used in the exemplifying embodiments shown in the other figures.

The exemplifying embodiment shown in Fig. 8 is substantially similar to that shown in Fig. 7, but in this embodiment the web W is passed from the coating device 10

through the airborne web dryer 15 operating as a pre-dryer over the drying cylinders 61,62 into dryer groups that apply a normal single-wire draw.

The exemplifying embodiment shown in Fig. 9 is substantially similar to that shown in Fig. 8, and in this embodiment, after the coating device 10, the coated paper web W is passed through the airborne web dryer 15 over the cylinders 61,62 into the first normal dryer group with single-wire draw, after which the web W is passed over the drying cylinder 81 around the large-diameter roll 80, in connection with which roll an impingement drying equipment 85 is provided. The diameter of the large-diameter roll is 20...150 %, preferably 25...90 % larger than the diameter of the ordinary drying cylinders. After this, there follows the drying cylinder 82 in the lower row, from which the web W is passed over the drying cylinder 91 into a normal dryer group with single-wire draw, whose reversing rolls/cylinders are denoted with the reference numeral 95 and drying cylinders with the reference numeral 93. The drying wire is denoted with the reference numeral 96, and its guide rolls with the reference numeral 97.

In the exemplifying embodiment shown in Fig. 10, after the coating device 10, the paper web W is passed over the drying cylinder 101 onto the face of the large-diameter roll 100, in whose connection an impingement drying equipment 105 is fitted. The large-diameter roll 100 is followed by a drying cylinder 102 and by a reversing roll/cylinder 103, after which the web W is passed into a dryer group with twin-wire draw, which is substantially similar to that described above, for example, in relation to Fig. 1. In connection with the large-diameter roll 100, a drying wire 106 of its own is provided, whose guide rolls are denoted with the reference numeral 107. By means of the guide roll 107A the run of the drying wire is shifted so that it does not reach contact with the paper web W to be dried which runs over the drying cylinder 101.

In the exemplifying embodiment shown in Fig. 11, the paper web W, which was coated in the coating device 10, runs first over the drying cylinder 111 into a dryer group with twin-wire draw, in which the upper wire 114 runs guided by the guide

rolls 15 over the drying cylinders 112 and 113 and the lower wire 122 runs over the guide rolls 123 and the drying cylinder 121. The web W runs meandering from one row RA to the other RY, and between the rows RA,RY the web W has free unsupported draws. From the group with twin-wire draw the web W is passed into the next dryer group, onto the drying cylinder 131 in the lower row, where the web runs on support of the drying wire 136. After this the web is passed onto the reversing roll/cylinder 132 in the upper row, in connection with which an impingement drying equipment 135 is fitted. After this the web is passed back to the lower row and further onto the drying cylinders 141,142 in the upper row, and in the final part of the group an ordinary group with twin-wire draw is fitted, in which the wire that operates as the lower wire 136 is common with the wire running through the impingement dryer group, and the drying cylinders 141,142 in the upper row are provided with a drying-wire cycle 146 of their own with guide rolls 147. Over the guide roll 143 the web W is passed to possible further processing.

Figs. 12A...12B are schematic illustrations of the construction of the nozzle face of the impingement drying device, in which the blow holes are denoted with the reference N_2 and the exhaust air pipes with the reference N_1. The diameter of the exhaust air pipes N_1 is about 50...100 mm, preferably 75 mm, and the diameter of the blow holes is about 3...8 mm, most commonly 5 mm. The paper web W runs at a distance of about 10...150 mm, preferably 25 mm, from the face of the nozzle plate, and the nozzle chamber of the hood is denoted with the reference letter N. The cylinder face is denoted with the reference C. The open area of the blow holes in the nozzle plate in the area of the web W is about 1...5 % and most commonly 1.5 %. The velocity of air in the blow holes is about 40...150 metres per second, preferably 100 m.p.s. The air quantity that is blown is about 0.5...2.5 cu.m per second per sq.m, which is calculated for the effective area of the hood. Most commonly an air quantity of 1...1.5 cu.m per second per sq.m is used. The open area of the exhaust air pipes is 5...15 %, most commonly 10 %. In addition to the nozzle face illustrated in this figure, it is possible to use a commonly known slot nozzle construction, fluid nozzle construction, foil nozzle construction, or a direct-blow nozzle construction as well as, for example, infra dryers, as well as any of

those mentioned above alternatingly in the cross direction of the machine as what is called combination dryers.

The impingement drying equipment to be used in connection with the exemplifying embodiments illustrated above in Figs. 1 to 11 can be an arrangement of a number of different types and in itself known to a person skilled in the art, in which arrangement drying air flows are blown towards the web to be dried. The impingement drying equipment can be constructed in blocks in the running direction S of the web or in the direction transverse to the running direction, in which case each block can be regulated separately if necessary.

In the exemplifying embodiment shown in Fig. 13, after the coating device 10, the paper web W is passed onto the drying cylinder 151, in whose connection an infra drying equipment 152 is fitted. After this the paper web to be dried is passed over the reversing blow box 153 onto the drying cylinder 154 and further onto a reversing roll or a drying cylinder or equivalent 155. In connection with the cylinder/roll 154, an impingement drying equipment 156 is fitted, which can be opened in the way indicated by the arrows S156 for cleaning. The wire draw takes place as a normal single-wire draw as described above in relation to the preceding figures. By means of the coating device 10 the coating is applied to the wire side, i.e., as shown in the figure, to the bottom side of the web face W. The hot exhaust air of the infra dryer 152 is passed along the duct 157 through a blower 158 for use in the impingement dryer 156. This infra-heated air can be used directly as impingement blow air, for example, to replace air that would have to be heated otherwise, or as pre-heated air in the burner in which said blow air for the impingement dryer is heated, or as replacement air for the impingement dryer. The impingement drying equipment 156 can be openable towards the bottom by means of pivot members 171.

The exemplifying embodiment shown in Fig. 14 represents an arrangement in which the coating of the web W by means of the coating device 10 is applied to the top side of the web, and the web W is dried first by means of an infra/gas dryer 161, after which the run of the web W is turned by means of a reversing blow box 162

and the web W is passed to run into a group with inverted single-wire draw, in which, in connection with the reversing rolls/cylinders 163,165, impingement drying devices 167 are provided. The exhaust air from the infra/gas dryer 161 is used as drying air for the impingement drying, and the exhaust gas is passed through the ducts 168 and through the blower 169 into the air system of the impingement drying.

Above, the invention has been described with reference to some preferred exemplifying embodiments of same only, and the invention is, however, by no means supposed to be confined to the details of said embodiments. Many variations and modifications are possible within the scope of the inventive idea defined in the following claims.

Claims

1. A method for drying a surface-treated paper web or equivalent in an after-dryer of a paper machine, in which method the paper web (W) is first finished in a finishing section, in which finishing section the paper web (W) is surface-sized or coated by means of a finishing device (10), after which the paper web (W) is dried, **characterized** in that in the after-dryer the paper web (W) is dried in at least one dryer group that makes use of single-wire draw, and that, at the same time, the paper web (W) is dried by means of an impingement-drying equipment (25;55;79; 85;105;135;156;167) fitted in connection with at least one cylinder or roll (23,24;53, 54;78;80;100;132;154;163,165) in said dryer group.

2. A method as claimed in claim 1, **characterized** in that after the paper web (W) finishing device (10) the paper web (W) is passed over a drying cylinder (21) into a dryer group with inverted single-wire draw, that in said dryer group the paper web (W) is dried by means of an impingement drying device (25) fitted in connection with a reversing cylinder or roll (23,24) in the upper row (RY) and by means of drying cylinders (22) placed in the lower row (RA), and that after this the paper web (W) is passed into a dryer group with twin-wire draw.

3. A method as claimed in claim 1 or 2, **characterized** in that, in the method, after the finishing device (10) the paper web (W) is pre-dried by means of an airborne web dryer (15).

4. A method as claimed in any of the claims 1 to 3, **characterized** in that after the finishing device (10) the paper web (W) is passed over a reversing blow device (14) to pre-drying taking place in an airborne web dryer (15).

5. A method as claimed in any of the claims 1 to 3, **characterized** in that after the finishing device (10) the paper web (W) is passed over a reversing blow device (14) into a dryer group with inverted single-wire draw, in which group the paper web (W) is dried in connection with the reversing cylinders/rolls (23,24) in the upper row

(RY) by means of an impingement drying device (25) and in the lower row (RA) by means of drying cylinders (22).

6. A method as claimed in claim 1, **characterized** in that after the finishing device (10) the paper web (W) is passed over a reversing blow device (14) into a dryer group with inverted single-wire draw, in which group, in connection with the reversing cylinders/rolls (23,24) in the upper row (RY), the paper web is dried by means of an impingement drying device (25), and in the lower row (RA) the paper web (W) is turned by means of a reversing blow device (28).

7. A method as claimed in claim 1, **characterized** in that, in the method, after the finishing device (10), the paper web (W) is passed over a drying cylinder (21) into a dryer group with normal single-wire draw, in which group the paper web (W) is dried in the upper row (RY) by means of drying cylinders (51,52) and in the lower row (RA) by means of an impingement drying device (55) fitted in connection with reversing rolls/cylinders (53,54), after which the paper web (W) is passed into a dryer group with twin-wire draw.

8. A method as claimed in claim 1, **characterized** in that after the finishing device (10) the paper web (W) is passed over two drying cylinders (61,62) into a dryer group with normal single-wire draw, in which group the paper web (W) is dried by means of drying cylinders (63) placed in the upper row (RY), and that the paper web (W) is passed into a second dryer group with normal single-wire draw over a drying cylinder (64), and that in the second group with single-wire draw the paper web (W) is dried by means of drying cylinders (73) placed in the upper row (RY) and by means of impingement drying devices (79) fitted in connection with at least some of the reversing rolls/cylinders (78) in the lower row (RA).

9. A method as claimed in claim 1 or 8, **characterized** in that, in the method, after the finishing device (10), the paper web (W) is passed to pre-drying taking place in an airborne web dryer (15).

10. A method as claimed in claim 1, **characterized** in that, in the method, after the finishing device (10), the paper web (W) is passed over two drying cylinders (61,62) into a dryer group with normal single-wire draw, after which the paper web is passed into a second dryer group with single-wire draw, in which group the paper web (W) is dried by means of a large-diameter cylinder (80) placed in the upper row (RY) and by means of an impingement drying equipment (85) placed in connection with said cylinder (80), after which the paper web (W) is dried in a third dryer group with normal single-wire draw.

11. A method as claimed in claim 10, **characterized** in that the paper web (W) is pre-dried by means of an airborne web dryer.

12. A method as claimed in claim 1, **characterized** in that, in the method, after the finishing device (10), the paper web (W) is passed over a drying cylinder (101) in the lower row (RA) onto a large-diameter reversing roll/cylinder (100) in the upper row (RY), in connection with which roll/cylinder the paper web (W) is dried by means of an impingement drying device (105), after which the paper web (W) is passed onto a drying cylinder (102) in the lower row (RA) and after that, over a reversing roll or cylinder (103), into a dryer group with twin-wire draw.

13. A method as claimed in claim 1, **characterized** in that after the finishing device (10) the paper web (W) is passed over a drying cylinder (111) into a dryer group with twin-wire draw, from which the paper web is passed into a dryer group with single-wire draw, in which the paper web (W) is dried by means of the drying cylinders (131,132) in the lower row (RA) and by means of an impingement drying equipment (135) placed in connection with a reversing roll/cylinder (132) in the upper row (RY), after which the paper web (W) is passed into a dryer group with twin-wire draw.

14. A method as claimed in claim 1, **characterized** in that after the finishing device (10) the paper web (W) is pre-dried by means of an infra dryer (152;161), and that the web (W) is passed into a dryer group with single-wire draw, in which the paper

web (W) is dried by means of an impingement drying equipment (156;167) fitted in connection with a roll or cylinder (154;163,165), and that in the method the exhaust air from the infra dryer (152;161) is passed to be used in the impingement drying device (156;167).

15. A method as claimed in any of the preceding claims, **characterized** in that, in the method, the paper web (W) is passed from one dryer group into the other as a closed draw.

16. An after-dryer for a paper machine for applying the method as claimed in any of the claims 1 to 15 to the drying of a surface-treated paper web or equivalent, which after-dryer is placed after the finishing device (10), by means of which finishing device (10) the paper web (W) is surface-sized or coated, **characterized** in that the after-dryer comprises at least one dryer group that applies single-wire draw, and an impingement-drying equipment (25;55;79;85;105;135;156;167) is fitted in connection with at least one cylinder or roll (23,24;53,54;78;80;100;132;154; 163,165) in said dryer group.

17. An after-dryer as claimed in claim 16, **characterized** in that the after-dryer comprises a dryer group with inverted single-wire draw placed after the finishing device (10), in which dryer group, in connection with a reversing cylinder or roll (23,24) in the upper row (RY), there is an impingement drying equipment (25), and (the after dryer comprises) a dryer group with twin-wire draw placed after said dryer group with single-wire draw.

18. An after-dryer as claimed in claim 16 or 17, **characterized** in that the pre-dryer in the after-dryer is an airborne web dryer (15).

19. An after-dryer as claimed in any of the claims 16 to 18, **characterized** in that, after the finishing device (10), a reversing blow device (14) is placed.

20. An after-dryer as claimed in claim 16, **characterized** in that a reversing blow device (28) is placed in the lower row (RA) in the dryer group with single-wire draw.

21. An after-dryer as claimed in claim 16, **characterized** in that after the finishing device (10) a dryer group with normal single-wire draw is placed, an impingement drying device (55) being fitted in connection with the reversing rolls/cylinders (53,54) in the lower row (RA) in said dryer group, and said dryer group is followed by a dryer group with twin-wire draw.

22. An after-dryer as claimed in claim 16, **characterized** in that the after-dryer comprises two dryer groups with single-wire draw placed one after the other, an impingement drying device (79) being fitted in connection with at least some of the reversing rolls/cylinders in the lower row (RA) in one of said single-wire groups.

23. An after-dryer as claimed in claim 22, **characterized** in that the after-dryer includes an airborne web dryer (15).

24. An after-dryer as claimed in claim 16, **characterized** in that the after-dryer comprises a dryer group in which there is a large-diameter cylinder or roll (80;100) and an impingement drying equipment (85) fitted in connection with said cylinder or roll.

25. An after-dryer as claimed in claim 16, **characterized** in that the after-dryer comprises first a dryer group with twin-wire draw and a subsequent dryer group with single-wire draw, in which latter group an impingement drying equipment (135) is fitted in connection with a reversing roll/cylinder (132) in the upper row (RY).

26. An after-dryer as claimed in claim 16, **characterized** in that the after-dryer comprises an infra dryer (152;161) and an impingement drying equipment (156;167) and a duct (157;168) and a blower (158,169) for passing the exhaust air from the infra dryer to be used in the impingement drying device (156;167).

27. An after-dryer as claimed in any of the preceding claims 16 to 26, **characterized** in that between the dryer groups in the after-dryer there is a closed draw of the paper web (W).

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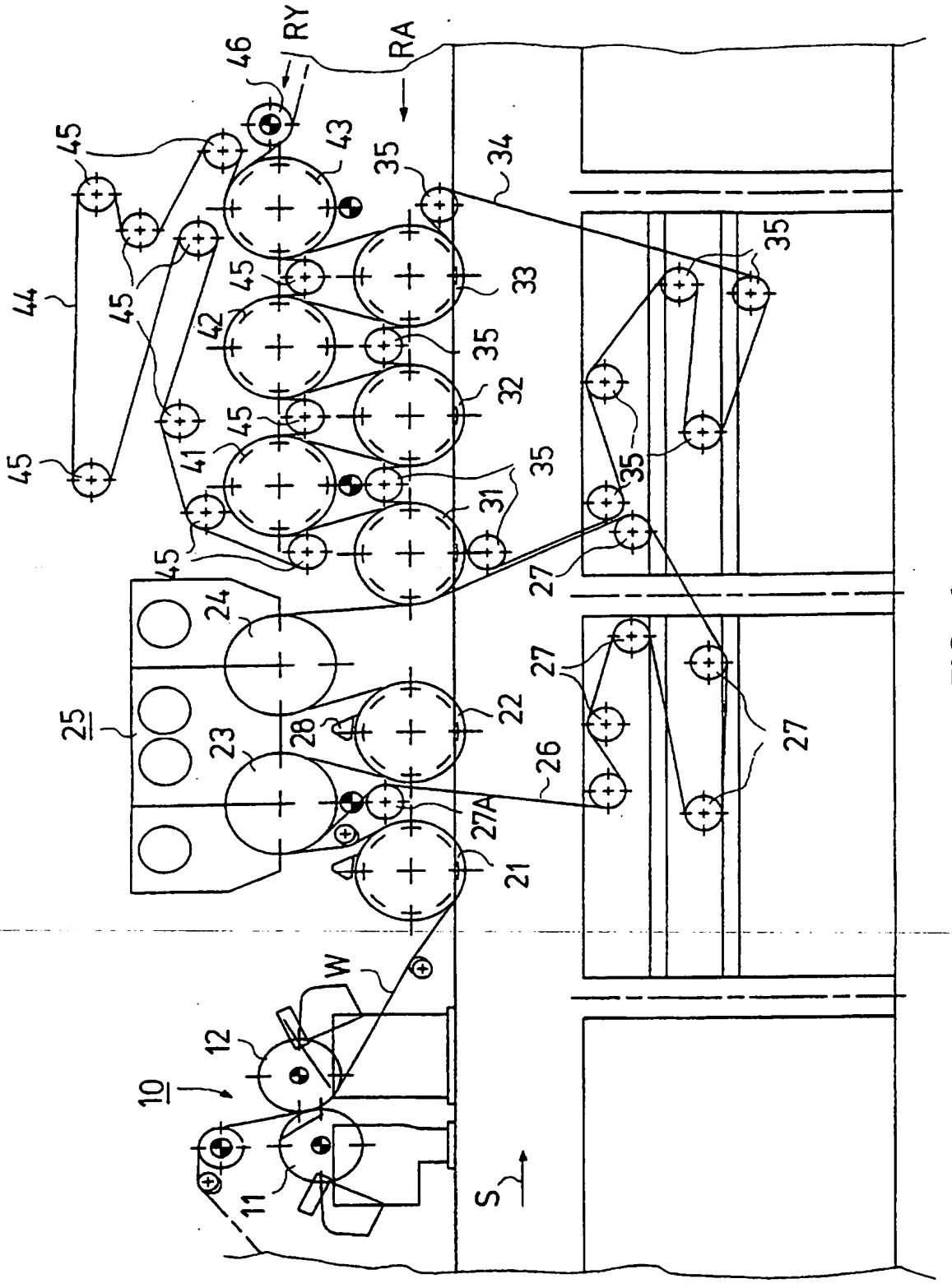
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FIG. 1

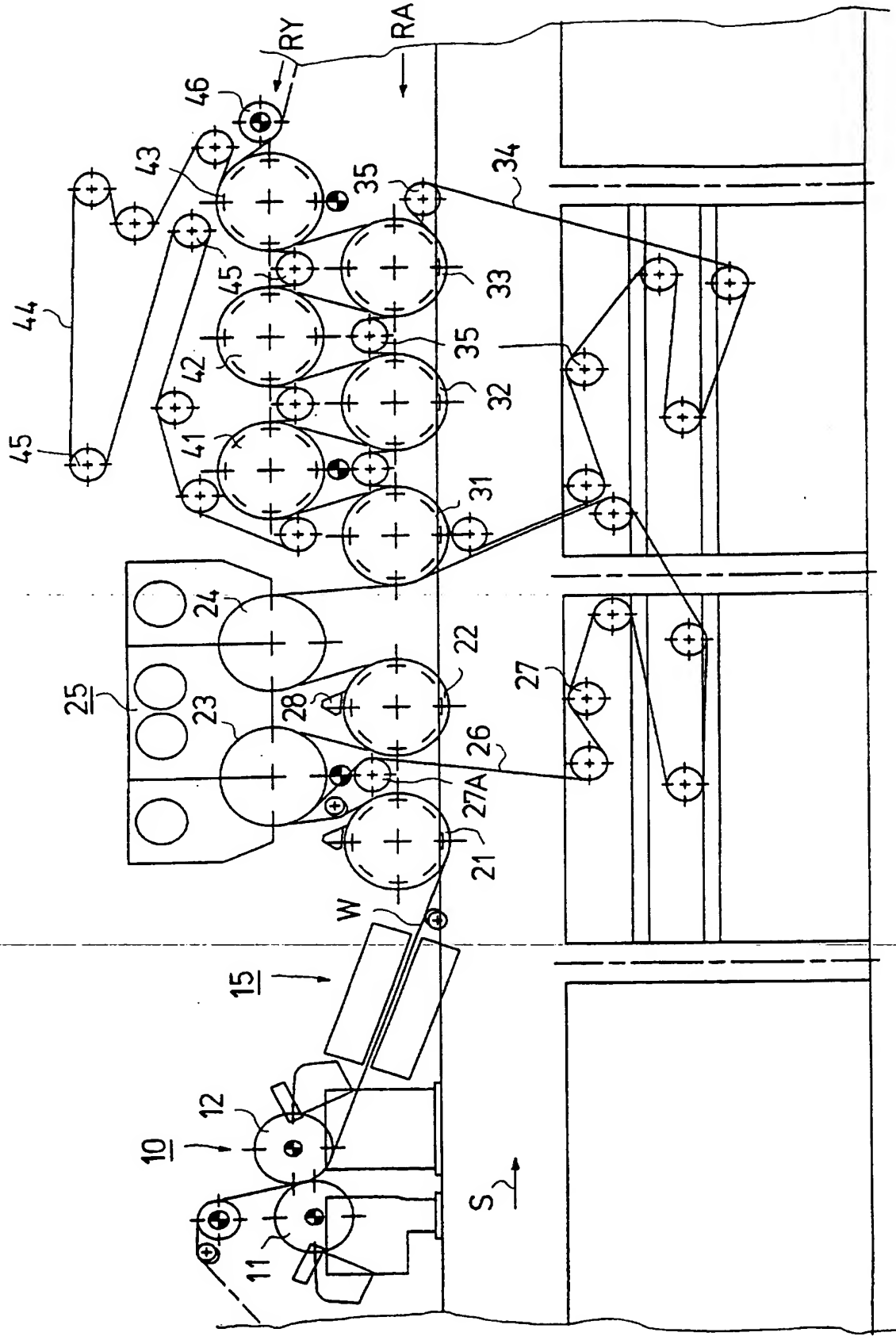
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FIG. 2

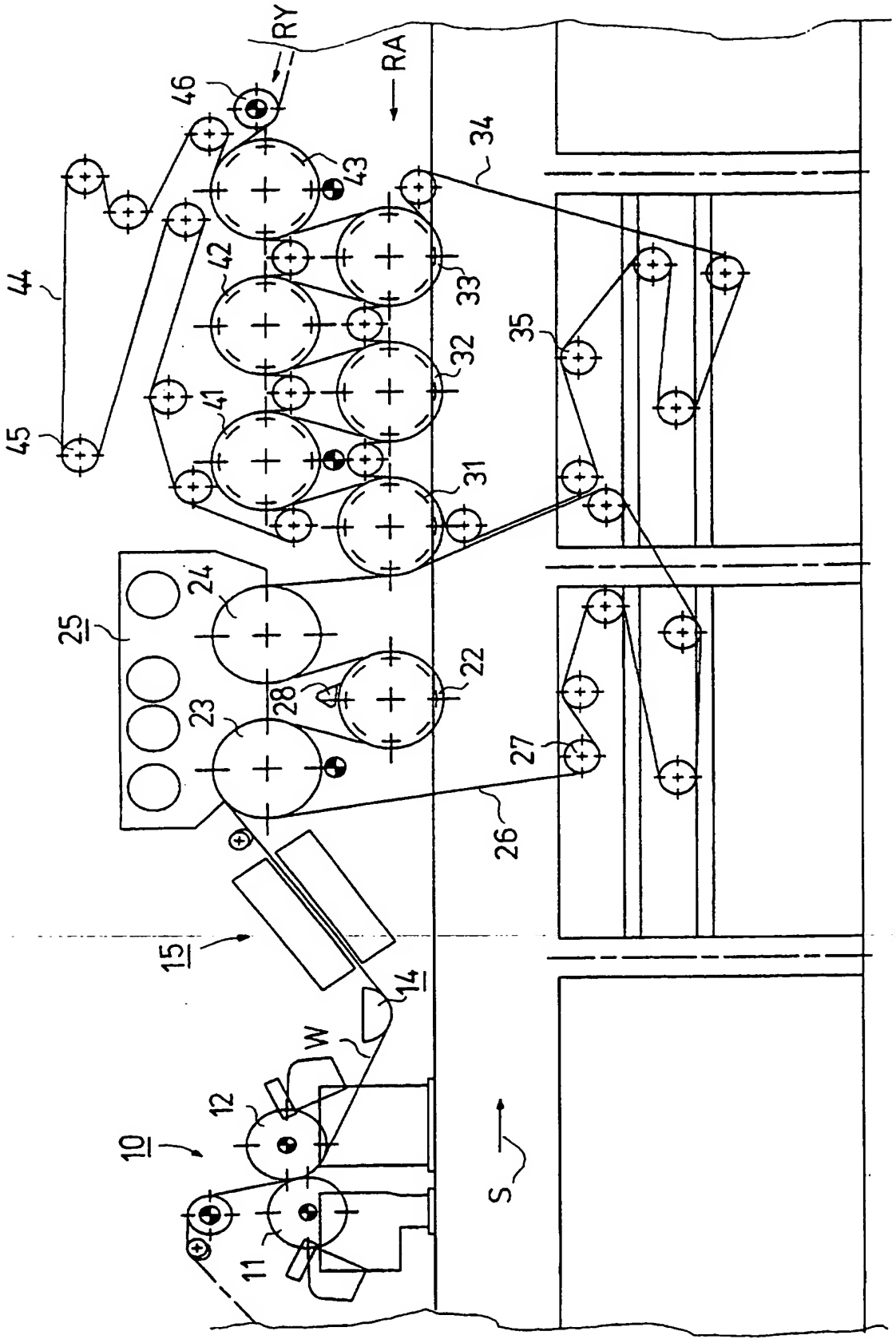
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FIG. 3

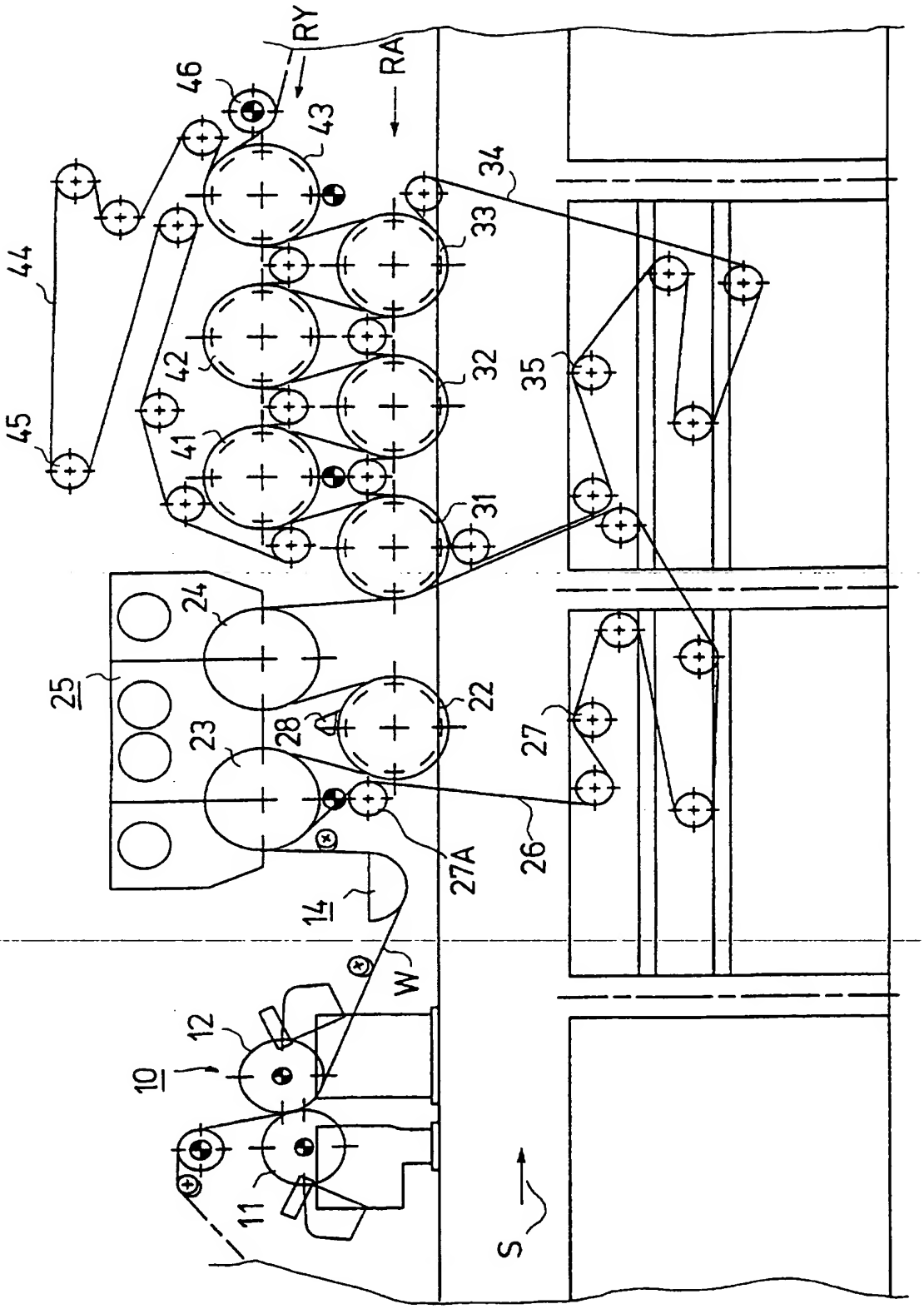
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FIG. 4

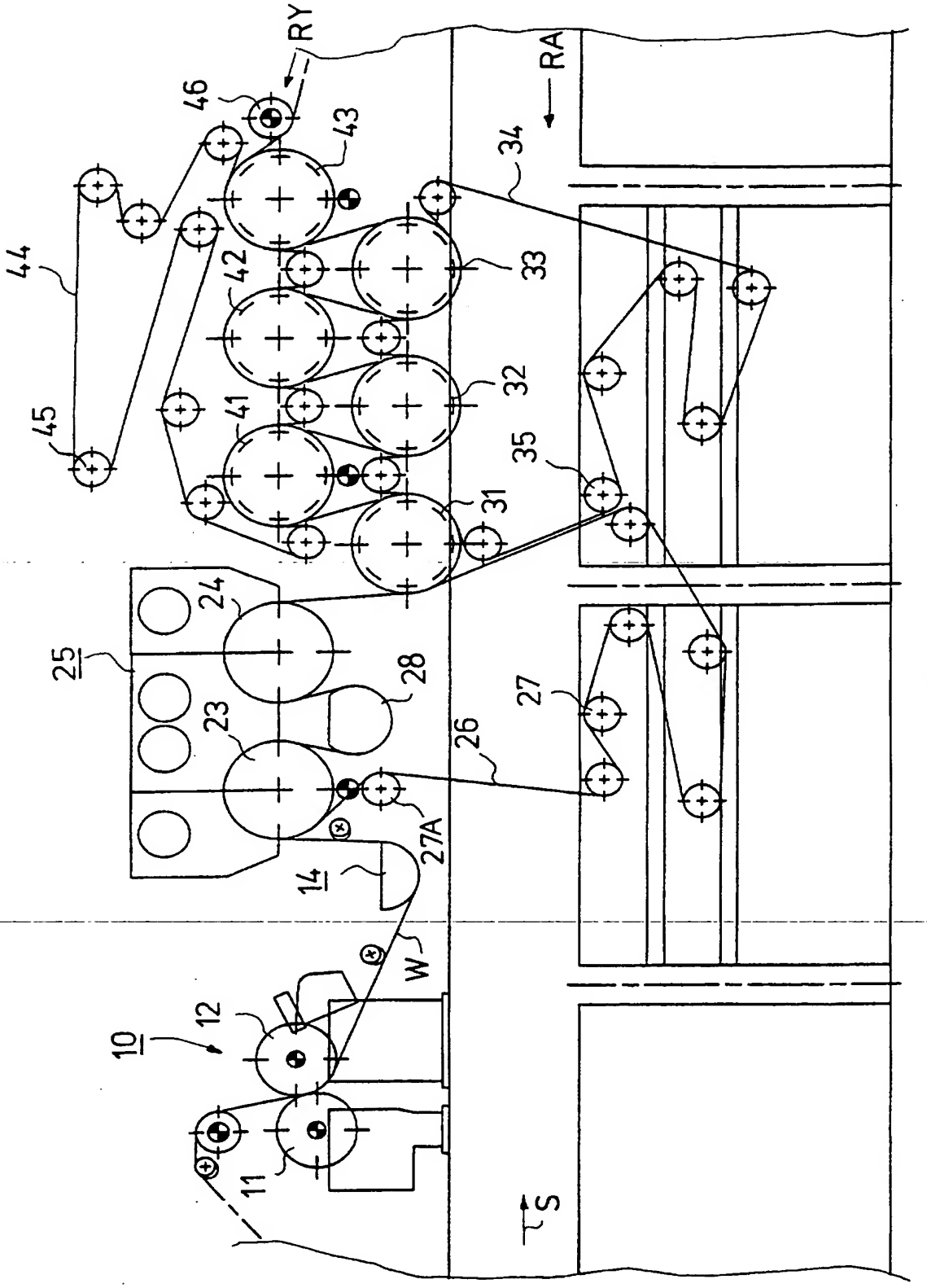
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FIG. 5

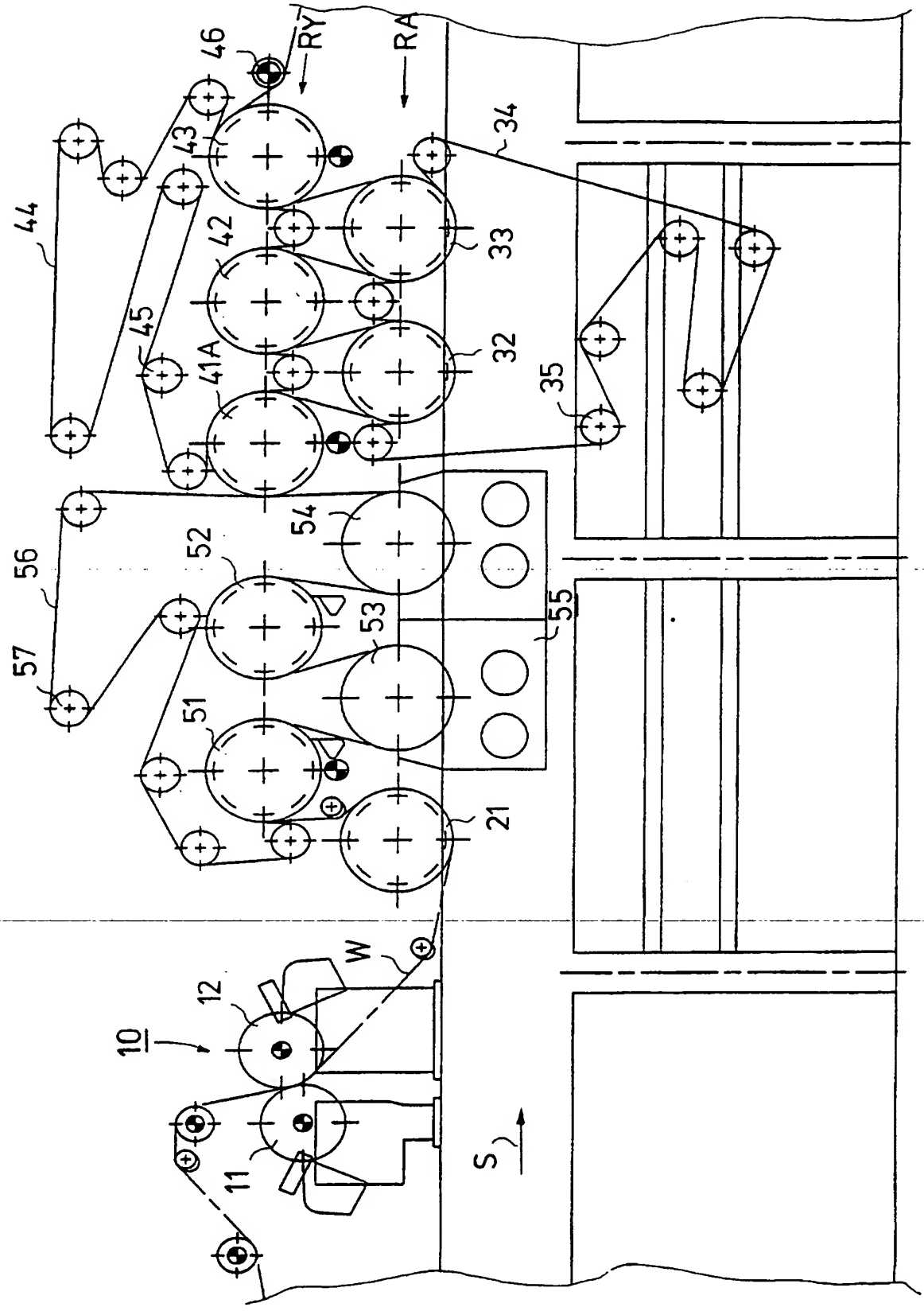
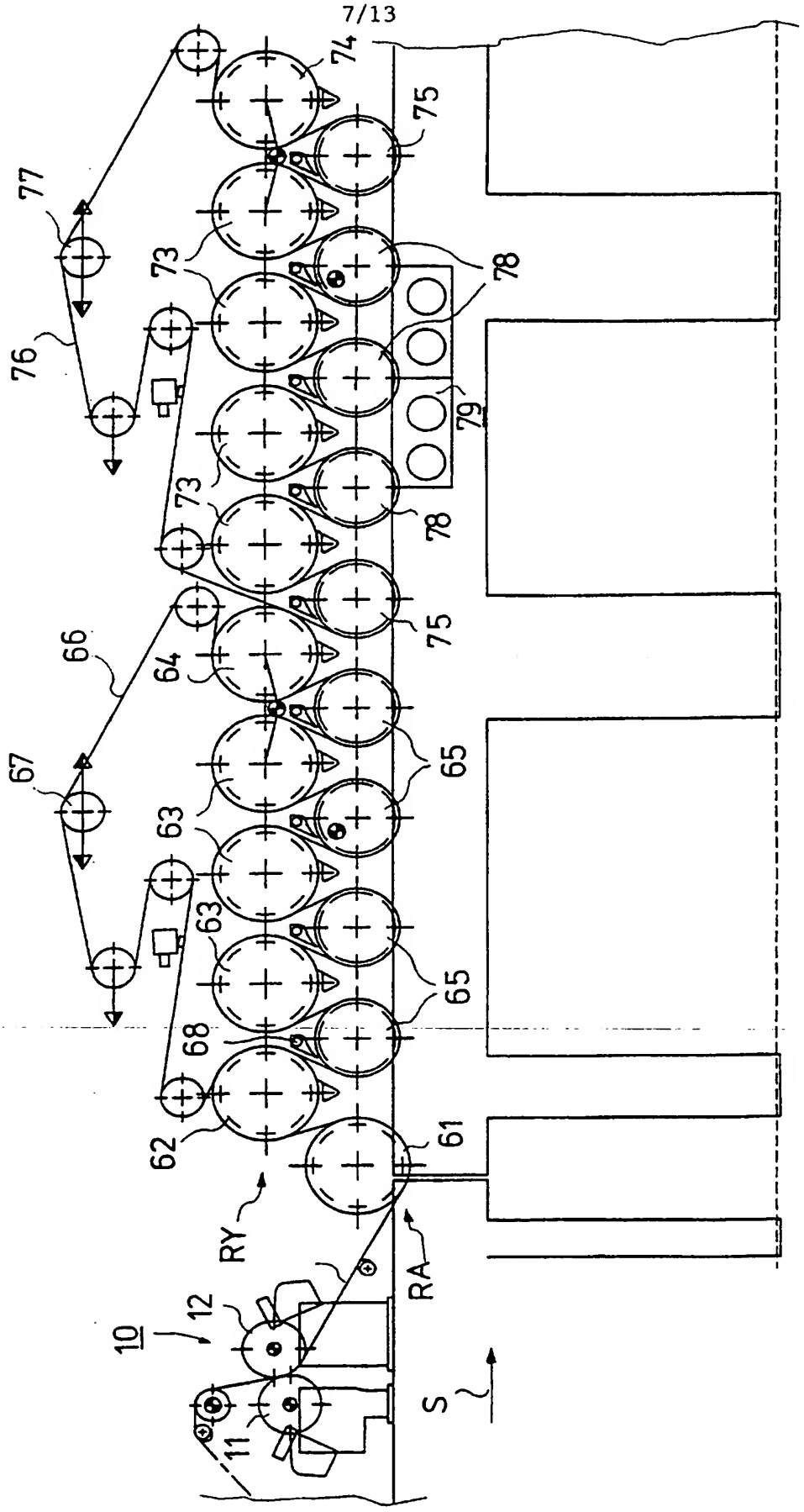


FIG. 6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RY
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FIG. 7

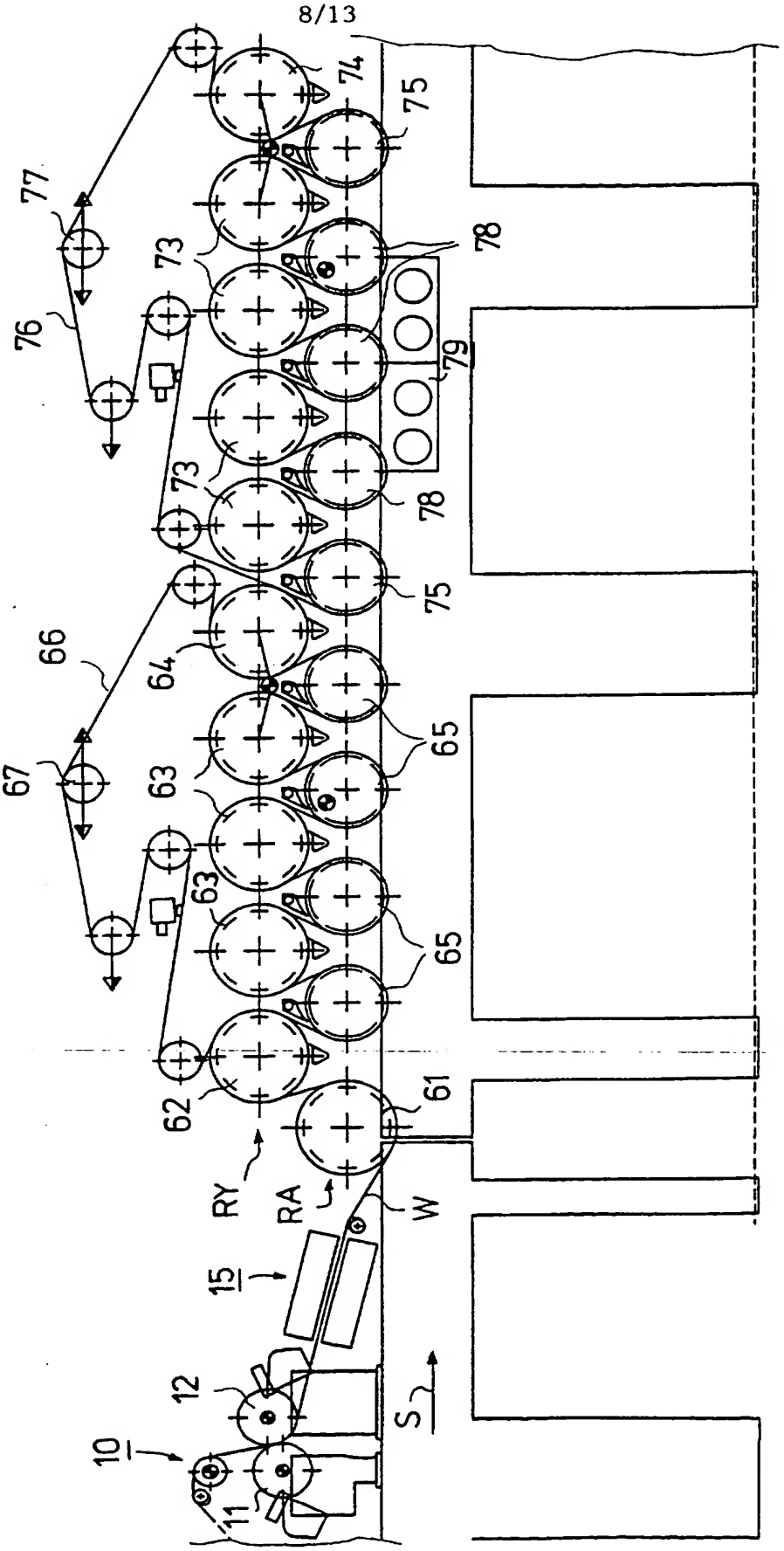
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FIG. 8

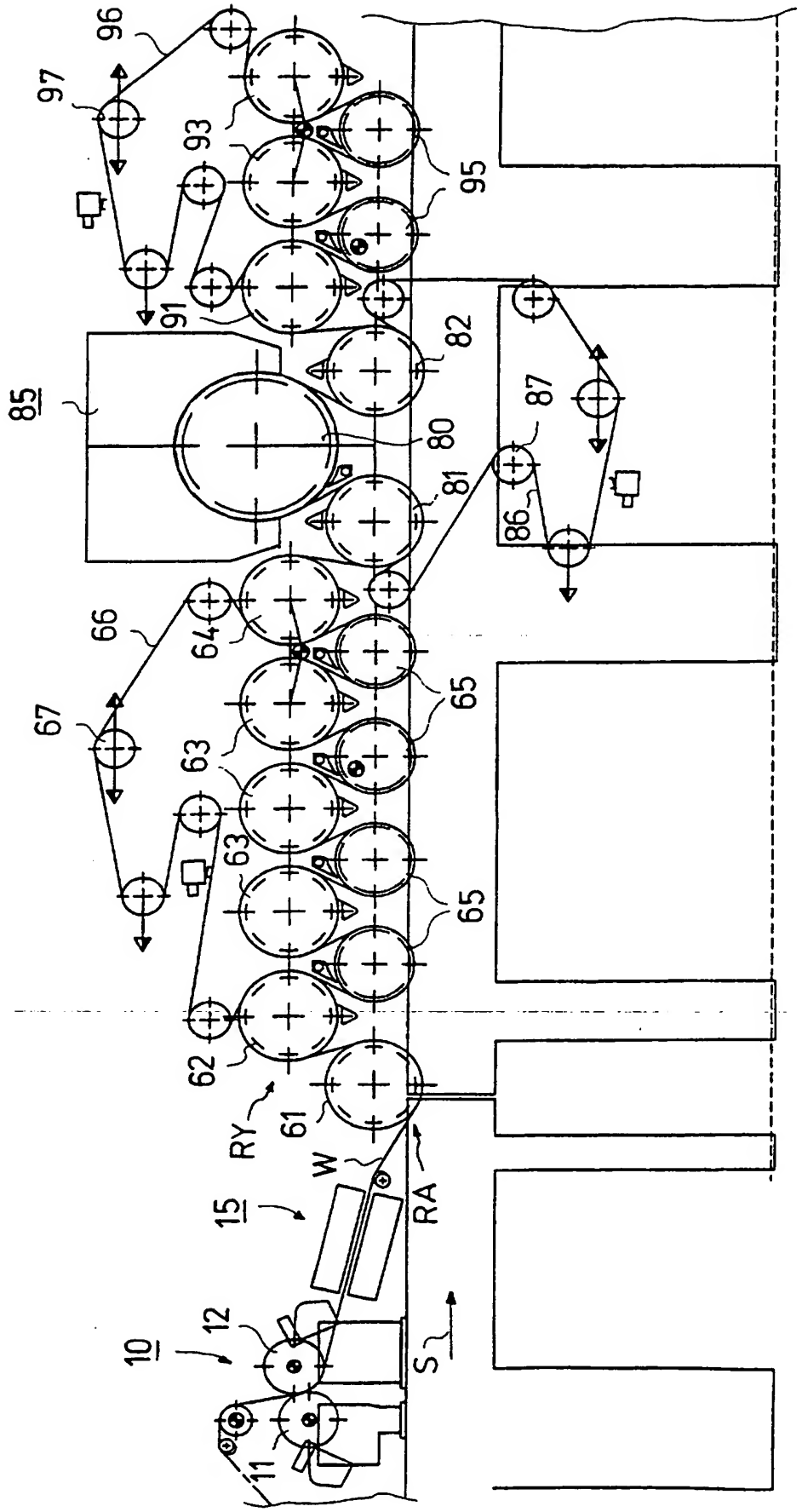
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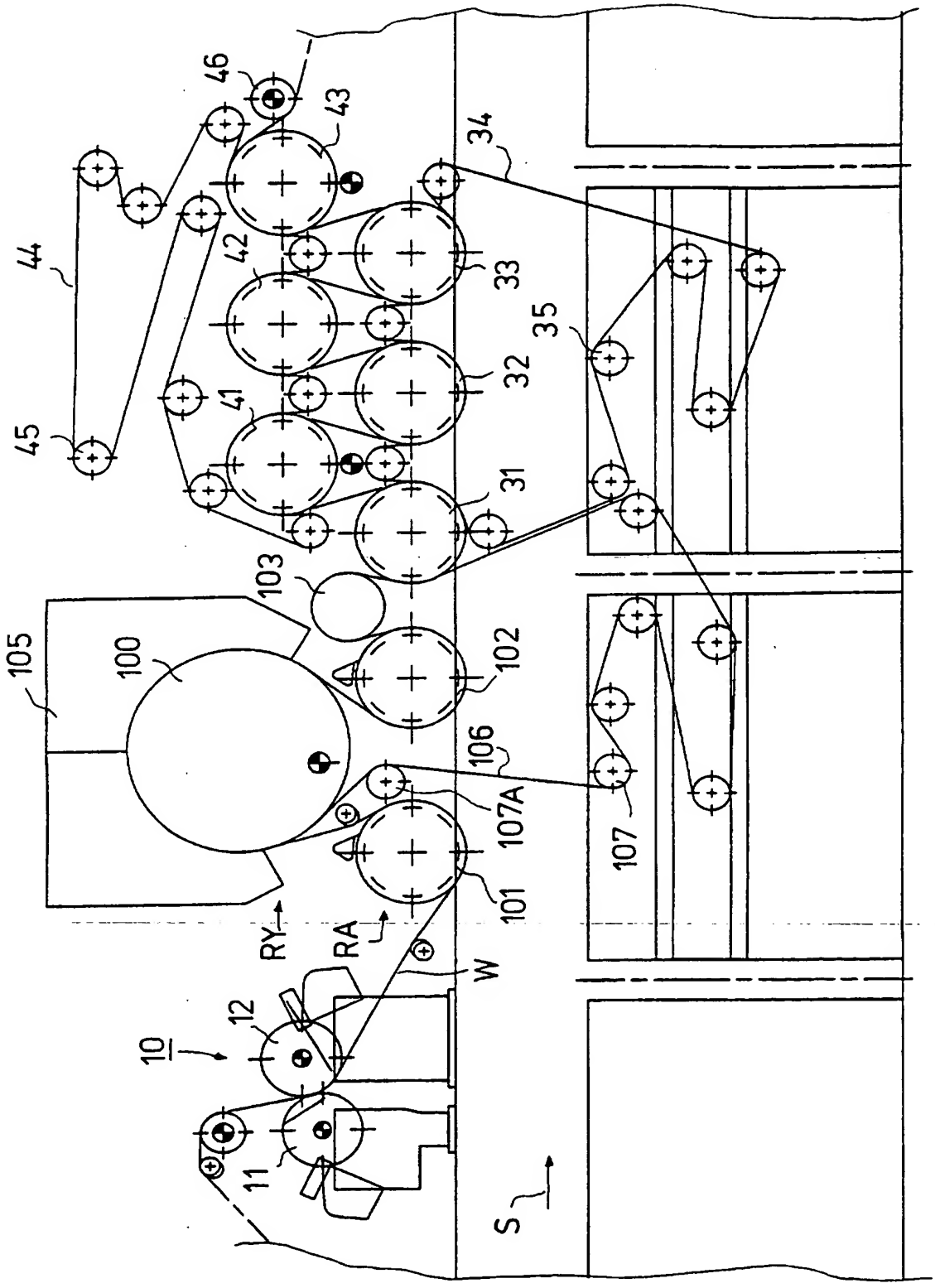
FIG. 9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W
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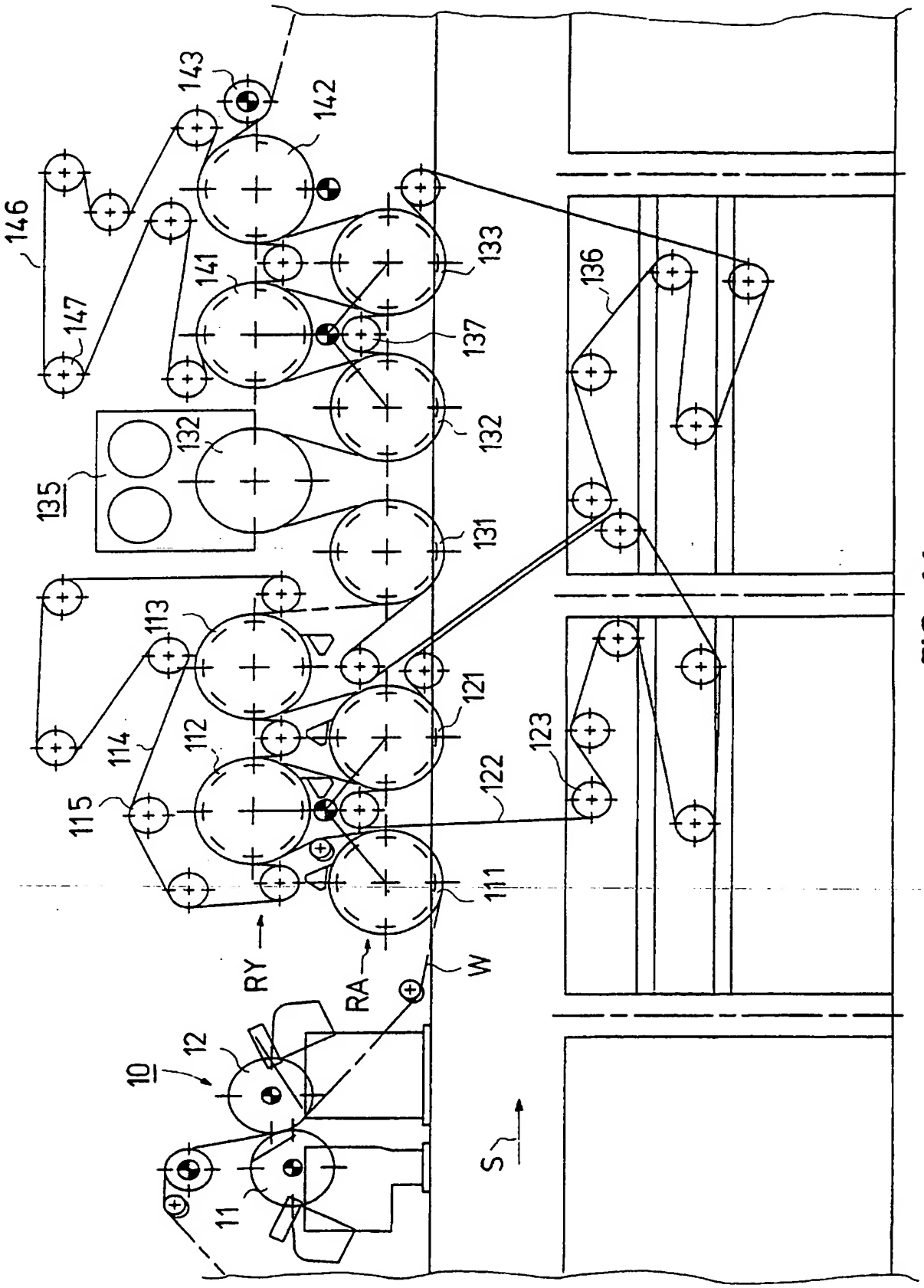
S

FIG. 10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RY
RA
W
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FIG. 11

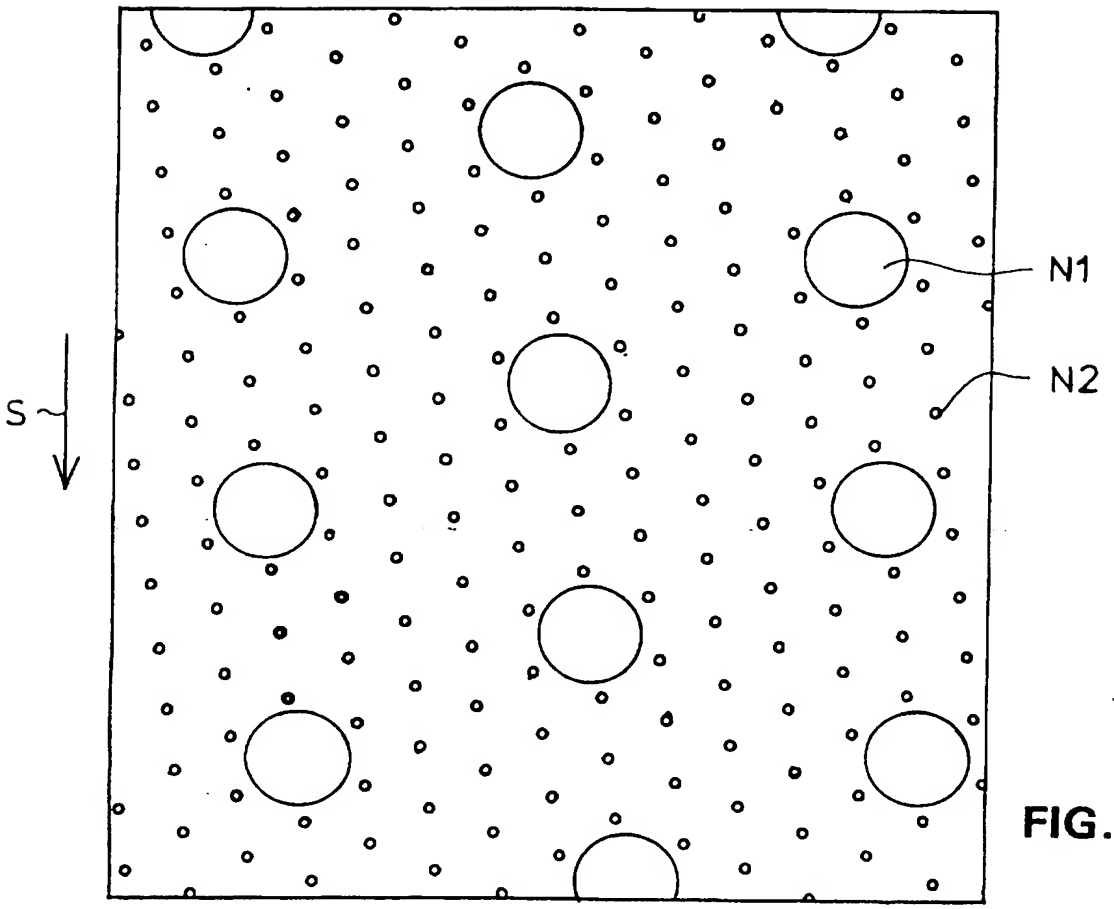


FIG. 12A

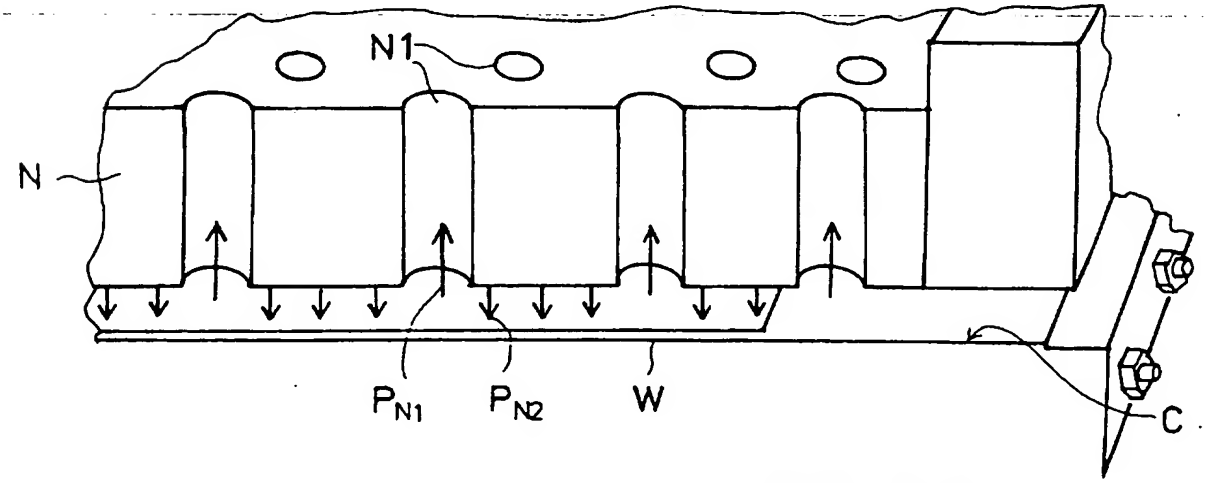
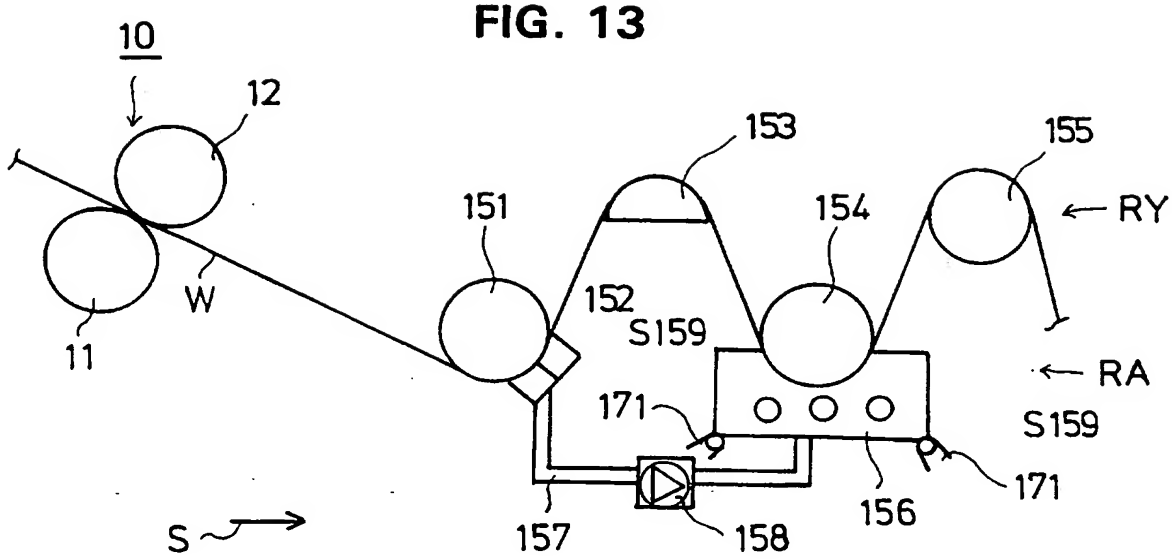


FIG. 12B

FIG. 13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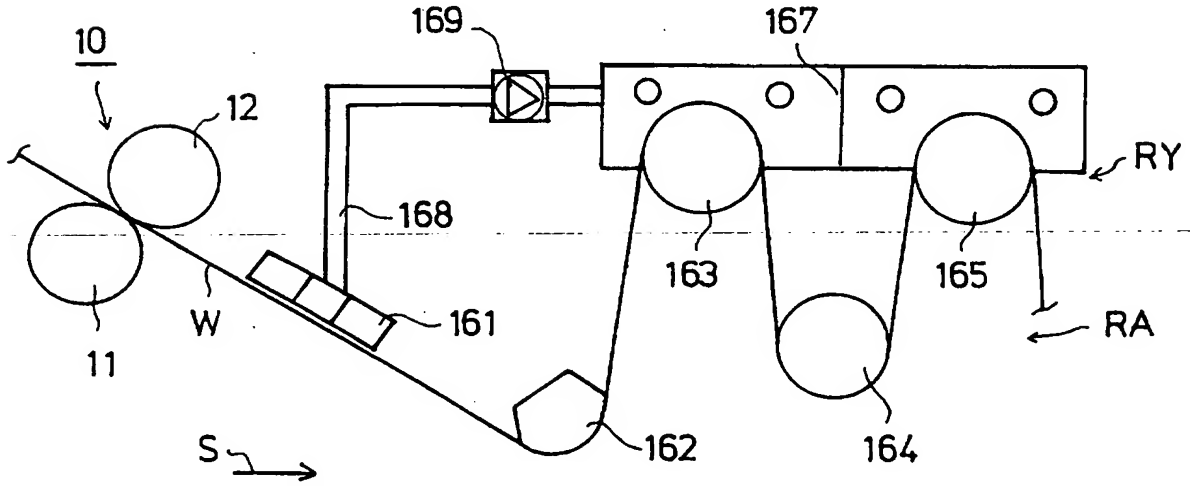
169
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RY
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W
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RA
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FIG. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 97/00532

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: D21F 5/04
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0726353 A2 (VALMET CORPORATION), 14 August 1996 (14.08.96), abstract, column 14, line 1 - line 28, column 16, line 44 - line 49, column 20, line 8 - line 11, line 31 - line 38 figure 1,2c,9,10 --	1-27
Y	EP 0620313 A2 (VALMET PAPER MACHINERY INC.), 19 October 1994 (19.10.94), page 7, line 46 - page 8, line 40, figures 1-5, abstract --	1-27

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 October 1997	03-12-1997
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Björn Salén Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/10/97

International application No.
PCT/FI 97/00532

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0726353 A2	14/08/96	CA 2167856 A	02/08/96
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		JP 8311793 A	26/11/96
EP 0620313 A2	19/10/94	CA 2119324 A	23/09/94
		FI 13 B	15/08/97
		FI 100013 B	00/00/00
		FI 931263 A	23/09/94
		US 5495678 A	05/03/96
		US 5653041 A	05/08/97